

Doubly Multivariate Within-cases on the Tubes Data

```

/***** tuberep.sas *****/
/* Not necessarily the best analysis -- just an example */
/*****/

%include 'tuberead2.sas';
title2 'Doubly multivariate repeated measures';

proc glm;
  title3 'Main Effect for MCG on length AND number of sclerotia';
  class mcg;
  model length4-length7 pmscl4-pmscl7 = mcg;
  manova H = mcg
    M = length4 + length5 + length6 + length7,
        pmscl4 + pmscl5 + pmscl6 + pmscl7
    mnames = avelen avescl / summary;
  /* The summary option requests univariate results on the transformed
     variables. */

proc glm;
  title3 'Main Effect of Time and Time*mcg interaction for both DVs';
  class mcg;
  model length4-length7 pmscl4-pmscl7 = mcg;
  manova H = intercept mcg
    M = length5-length4, length6-length5, length7-length6,
        pmscl5-pmscl4, pmscl6-pmscl5, pmscl7-pmscl6
    mnames = lgrow45 lgrow56 lgrow67
            sgrow45 sgrow56 sgrow67 / summary;

proc glm;
  title3 'Main Effect of Time and Time*mcg, interaction, just for length';
  class mcg;
  model length4-length7 = mcg;
  manova H = intercept mcg
    M = length5-length4, length6-length5, length7-length6
    mnames = lgrow45 lgrow56 lgrow67 / summary;

proc glm;
  title3 'Main Effect of Time and Time*mcg interaction, just sclerotia';
  class mcg;
  model pmscl4-pmscl7 = mcg;
  manova H = intercept mcg
    M = pmscl5-pmscl4, pmscl6-pmscl5, pmscl7-pmscl6
    mnames = sgrow45 sgrow56 sgrow67 / summary;

/* When you compose your own transformations for a within cases analysis,

1. Main effects of between cases factors correspond to main effects on
   sums or averages of the dependent variables.

2. Main effects of within-cases factors are represented by the
   intercept, for a collection of difference variables.

3. Between by within interactions are represented by main effects of the
   between factors on collections of difference variables.
```

In this last run of proc glm, we just verify that the "repeated" syntax gives us the same test statistics as the job above, just for the length variables. */

```
proc glm;
  title3 'Check using REPEATED syntax, just for length';
  class mcg;
  model length4-length7 = mcg;
  repeated time profile / short summary;
```

```

      Fungus Tube data with line1=113 eliminated
      Doubly multivariate repeated measures
Main Effect for MCG on length AND number of sclerotia
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      The GLM Procedure

      Class Level Information

Class          Levels      Values
-----
mcg              6      198 205 213 221 223 225

      Number of Observations Read          23
      Number of Observations Used          23
```

For each run of proc glm, the output starts with univariate analyses of each (untransformed) dependent variable. We will skip these from now on. The following is one big M transformation matrix (2x4), split into two parts for printing.

```

      Fungus Tube data with line1=113 eliminated
      Doubly multivariate repeated measures
Main Effect for MCG on length AND number of sclerotia
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      The GLM Procedure
      Multivariate Analysis of Variance

      M Matrix Describing Transformed Variables

length4          length5          length6          length7
-----
avelen              1              1              1              1
avescl              0              0              0              0

      M Matrix Describing Transformed Variables

pmscl4          pmscl5          pmscl6          pmscl7
-----
avelen              0              0              0              0
avescl              1              1              1              1
```

We'll also routinely skip the "Characteristic Roots and Vectors," going directly to the test statistics.

Fungus Tube data with line1=113 eliminated 11
 Doubly multivariate repeated measures
 Main Effect for MCG on length AND number of sclerotia

MANOVA Test Criteria and F Approximations for
 the Hypothesis of No Overall mcg Effect
 on the Variables Defined by the M Matrix Transformation
 H = Type III SSCP Matrix for mcg
 E = Error SSCP Matrix

S=2 M=1 N=7

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.03979791	12.84	10	32	<.0001
Pillai's Trace	1.41482740	8.22	10	34	<.0001
Hotelling-Lawley Trace	12.70360165	19.62	10	21.419	<.0001
Roy's Greatest Root	11.72972117	39.88	5	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

NOTE: F Statistic for Wilks' Lambda is exact.

The univariate tests on the transformed dependent variables are of interest. There are obtained with the summary option.

Fungus Tube data with line1=113 eliminated 12
 Doubly multivariate repeated measures
 Main Effect for MCG on length AND number of sclerotia

The GLM Procedure
 Multivariate Analysis of Variance

Dependent Variable: avelen

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	229.0887613	45.8177523	34.37	<.0001
Error	17	22.6652604	1.3332506		

The GLM Procedure
 Multivariate Analysis of Variance

Dependent Variable: avesc1

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	3451.246377	690.249275	4.66	0.0074
Error	17	2520.666667	148.274510		

Fungus Tube data with line1=113 eliminated
 Doubly multivariate repeated measures
 Main Effect of Time and Time*mcg interaction for both DVs

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The GLM Procedure
 Multivariate Analysis of Variance

M Matrix Describing Transformed Variables

	length4	length5	length6	length7
lgrow45	-1	1	0	0
lgrow56	0	-1	1	0
lgrow67	0	0	-1	1
sgrow45	0	0	0	0
sgrow56	0	0	0	0
sgrow67	0	0	0	0

M Matrix Describing Transformed Variables

	pmscl4	pmscl5	pmscl6	pmscl7
lgrow45	0	0	0	0
lgrow56	0	0	0	0
lgrow67	0	0	0	0
sgrow45	-1	1	0	0
sgrow56	0	-1	1	0
sgrow67	0	0	-1	1

This is the main effect for time. Why it's the "intercept" is a fairly long story, and depends on how proc glm parameterizes a linear model. Please just accept it for now.

MANOVA Test Criteria and Exact F Statistics for
 the Hypothesis of No Overall Intercept Effect
 on the Variables Defined by the M Matrix Transformation
 H = Type III SSCP Matrix for Intercept
 E = Error SSCP Matrix

Statistic	S=1	M=2	N=5	Num DF	Den DF	Pr > F
	Value	F Value				
Wilks' Lambda	0.0002071	9654.06		6	12	<.0001
Pillai's Trace	0.9997929	9654.06		6	12	<.0001
Hotelling-Lawley Trace	4827.0310267	9654.06		6	12	<.0001
Roy's Greatest Root	4827.0310267	9654.06		6	12	<.0001

This is the relationship of the between cases independent variable MCG to the collection of difference variables, so it's actually the time by MCG interaction.

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall mcg Effect
on the Variables Defined by the M Matrix Transformation
H = Type III SSCP Matrix for mcg
E = Error SSCP Matrix

	S=5	M=0	N=5		
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.00774399	3.95	30	50	<.0001
Pillai's Trace	2.14043985	2.00	30	80	0.0077
Hotelling-Lawley Trace	24.05484117	8.80	30	22.526	<.0001
Roy's Greatest Root	21.07866837	56.21	6	16	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

Now the univariate analyses of the transformed variables, which are useful for following up the multivariate tests.

Dependent Variable: lgrow45

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	210.5954633	210.5954633	5196.04	<.0001
mcg	5	0.4628374	0.0925675	2.28	0.0924
Error	17	0.6890104	0.0405300		

Dependent Variable: lgrow56

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	184.1403947	184.1403947	8292.42	<.0001
mcg	5	1.1472826	0.2294565	10.33	0.0001
Error	17	0.3775000	0.0222059		

Dependent Variable: lgrow67

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	199.4542215	199.4542215	7179.30	<.0001
mcg	5	0.8309692	0.1661938	5.98	0.0023
Error	17	0.4722917	0.0277819		

Dependent Variable: sgrow45

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	379.1052632	379.1052632	53.48	<.0001
mcg	5	136.1086957	27.2217391	3.84	0.0164
Error	17	120.5000000	7.0882353		

Dependent Variable: sgrow56

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	289.6885965	289.6885965	49.54	<.0001
mcg	5	34.0615942	6.8123188	1.16	0.3662
Error	17	99.4166667	5.8480392		

Dependent Variable: sgrow67

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Intercept	1	123.7894737	123.7894737	32.63	<.0001
mcg	5	38.3695652	7.6739130	2.02	0.1267
Error	17	64.5000000	3.7941176		

Within-cases analysis of length and number of sclerotia separately. Length comes first. Note that we already saw the tests for the main effects of mcg.

Fungus Tube data with line1=113 eliminated 37
 Doubly multivariate repeated measures
 Main Effect of Time and Time*mcg, interaction, just for length

The GLM Procedure
 Multivariate Analysis of Variance

M Matrix Describing Transformed Variables

	length4	length5	length6	length7
lgrow45	-1	1	0	0
lgrow56	0	-1	1	0
lgrow67	0	0	-1	1

MANOVA Test Criteria and Exact F Statistics for
the Hypothesis of No Overall Intercept Effect
on the Variables Defined by the M Matrix Transformation

H = Type III SSCP Matrix for Intercept
E = Error SSCP Matrix

S=1 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.0002313	21607.5	3	15	<.0001
Pillai's Trace	0.9997687	21607.5	3	15	<.0001
Hotelling-Lawley Trace	4321.4954877	21607.5	3	15	<.0001
Roy's Greatest Root	4321.4954877	21607.5	3	15	<.0001

Fungus Tube data with line1=113 eliminated

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Doubly multivariate repeated measures

Main Effect of Time and Time*mcg, interaction, just for length

The GLM Procedure
Multivariate Analysis of Variance

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall mcg Effect
on the Variables Defined by the M Matrix Transformation

H = Type III SSCP Matrix for mcg
E = Error SSCP Matrix

S=3 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.03671811	6.44	15	41.81	<.0001
Pillai's Trace	1.26374011	2.47	15	51	0.0083
Hotelling-Lawley Trace	18.40679276	17.43	15	23.537	<.0001
Roy's Greatest Root	17.99257284	61.17	5	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

We've already seen the univariate analyses of transformed variables – skip them, going to sclerotia.

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Fungus Tube data with line1=113 eliminated
 Doubly multivariate repeated measures
 Main Effect of Time and Time*mcg interaction, just sclerotia

The GLM Procedure
 Multivariate Analysis of Variance

M Matrix Describing Transformed Variables

	pmscl4	pmscl5	pmscl6	pmscl7
sgrow45	-1	1	0	0
sgrow56	0	-1	1	0
sgrow67	0	0	-1	1

MANOVA Test Criteria and Exact F Statistics for
 the Hypothesis of No Overall Intercept Effect
 on the Variables Defined by the M Matrix Transformation

H = Type III SSCP Matrix for Intercept (Time)
 E = Error SSCP Matrix

S=1 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.08535957	53.58	3	15	<.0001
Pillai's Trace	0.91464043	53.58	3	15	<.0001
Hotelling-Lawley Trace	10.71514782	53.58	3	15	<.0001
Roy's Greatest Root	10.71514782	53.58	3	15	<.0001

MANOVA Test Criteria and F Approximations for
 the Hypothesis of No Overall mcg Effect
 on the Variables Defined by the M Matrix Transformation

H = Type III SSCP Matrix for mcg (Time by MCG)
 E = Error SSCP Matrix

S=3 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.23572812	1.92	15	41.81	0.0494
Pillai's Trace	0.95954465	1.60	15	51	0.1073
Hotelling-Lawley Trace	2.46188585	2.33	15	23.537	0.0319
Roy's Greatest Root	2.12850469	7.24	5	17	0.0009

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

Now a cross-check, making sure that the test statistics using the M matrix are the same as what we get from repeated. Just check length. For comparison, had

Effect	Lambda	F	p
mcg		34.37	< 0.0001
time	0.0002313	21607.50	< 0.0001
mcg*time	0.03671811	6.44	< 0.0001

The GLM Procedure
Repeated Measures Analysis of Variance

Repeated Measures Level Information

Dependent Variable	length4	length5	length6	length7
Level of time	1	2	3	4

MANOVA Test Criteria and Exact F Statistics
for the Hypothesis of no time Effect
H = Type III SSCP Matrix for time
E = Error SSCP Matrix

S=1 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.0002313	21607.5	3	15	<.0001
Pillai's Trace	0.9997687	21607.5	3	15	<.0001
Hotelling-Lawley Trace	4321.4954877	21607.5	3	15	<.0001
Roy's Greatest Root	4321.4954877	21607.5	3	15	<.0001

MANOVA Test Criteria and F Approximations
for the Hypothesis of no time*mcg Effect
H = Type III SSCP Matrix for time*mcg
E = Error SSCP Matrix

S=3 M=0.5 N=6.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.03671811	6.44	15	41.81	<.0001
Pillai's Trace	1.26374011	2.47	15	51	0.0083
Hotelling-Lawley Trace	18.40679276	17.43	15	23.537	<.0001
Roy's Greatest Root	17.99257284	61.17	5	17	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.

Fungus Tube data with line1=113 eliminated 60
Tests of Hypotheses for Between Subjects Effects

Source	DF	Type III SS	Mean Square	F Value	Pr > F
mcg	5	57.27219033	11.45443807	34.37	<.0001
Error	17	5.66631510	0.33331265		